

# Advanced Additive Manufacturing Feedstock from Molten Regolith Electrolysis

Completed Technology Project (2016 - 2017)



## Project Introduction

Demonstrate the feasibility of Molten Regolith Electrolysis (MRE) Reactor start by initiating resistive-heating of the regolith past its melting point using electrical energy from the MRE electrode, taking this technology from TRL 1 to TRL3 and demonstrate the first use of metal products of MRE as feedstock for additive manufacturing of metal parts by a state-of-the-art 3D print technology. Containing corrosive oxide mixtures at operating temperatures in excess of 1500°C (2730 °F), determine the reactor start sequence, achieve longevity of electrodes and the regular removal of products from the reactor are the challenges faced. Design and fabricate first heater/electrode element. Select alloy compositions, synthesis approach, and cast first alloys. Design wire or powder fabrication experiment for feedstock production. Iterate design, and fabrication of the heater/electrode element. Produce feedstock batches and iterate. Characterize the metal feedstock (mechanical, electrical and thermal properties.) Demonstrate the effectiveness of the designed electrode/heating element by melting regolith using only the electrode/heating device in a large crucible inside a box furnace. Iteratively fabricate metal with improved feedstock. Characterize the representative parts. Perform microstructure analysis using scanning electron microscope and transmission electron microscope.

## Anticipated Benefits

Perform additive manufacturing with regolith feedstock using Molten Regolith Electrolysis (MRE). The production of raw materials such as metals, glasses, ceramics for In Space Fabrication and Repair (ISFR) along with by-product oxygen is potentially a paradigm-shifting step in space exploration. The rapid emergence of additive manufacturing benefits many sectors of industry and is paralleled by pioneering efforts within NASA to develop prototypes for In Space Fabrication. The fabrication of needed parts in space by these technologies must use raw materials feedstock that will either have been brought from Earth for such purpose (imported feedstock), obtained from damaged or discarded parts (recycled feedstock) or more sustainably extracted from space resources (produced feedstock). Theoretical and experimental MRE work performed by Kennedy Space Center (KSC) and university partners Massachusetts Institute of Technology (MIT) and Ohio State University previously funded by NASA defined the current state of the technology.



Advanced Additive  
Manufacturing Feedstock from  
Molten Regolith Electrolysis

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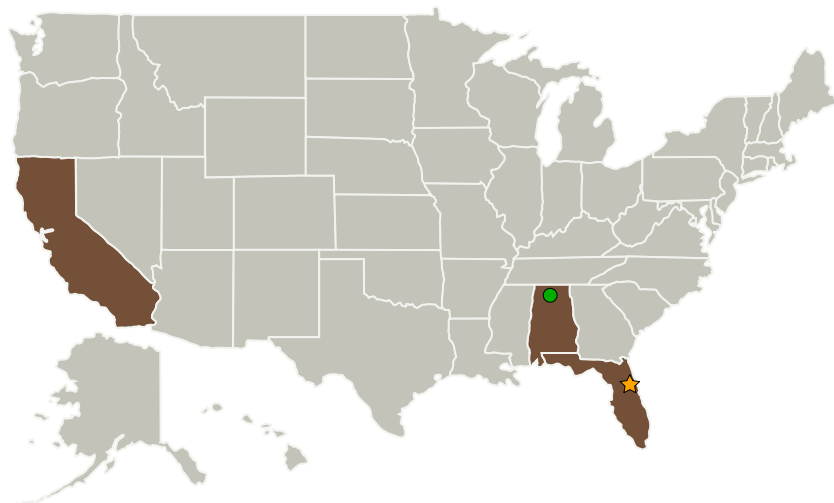
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## Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★ Kennedy Space Center(KSC)	Lead Organization	NASA Center	Kennedy Space Center, Florida
Made in Space, Inc.	Supporting Organization	Industry	JACKSONVILLE, Florida
● Marshall Space Flight Center(MSFC)	Supporting Organization	NASA Center	Huntsville, Alabama
University of Central Florida(UCF)	Supporting Organization	Academia	Orlando, Florida

### Primary U.S. Work Locations

Alabama	California
Florida	

## Organizational Responsibility

### Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

### Lead Center / Facility:

Kennedy Space Center (KSC)

### Responsible Program:

Center Innovation Fund: KSC CIF

## Project Management

### Program Director:

Michael R Lapointe

### Program Manager:

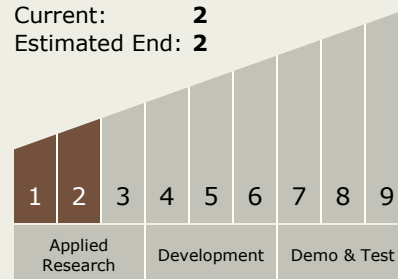
Barbara L Brown

### Principal Investigator:

Robert P Mueller

## Technology Maturity (TRL)

Start: **1**  
 Current: **2**  
 Estimated End: **2**



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## Technology Areas

### Primary:

- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
  - └ TX12.4 Manufacturing
    - └ TX12.4.6 Repurpose Processes

## Target Destination

Mars